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Compatible agri-horti systems and weed management options for Mungbean production

M. K. Singh*, O. P. Shivran and S. K. Prasad

Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi 221 005, U.P., India

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ABSTRACT

For increasing the production of mungbean, a field experiment was conducted in split plot design, to evaluate the compatible agri-horti system and efficient weed management practice. Keeping three agri-horti systems [guava, custard apple and open field] in the main-plots and six weed management practices [pendimethalin 1000 g a.i./ha (PE), imazethapyr 125 and 200 g a.i./ha (PoE), 1- HW (20 DAS), 2-HW (15 & 30 DAS) and weedy check] in sub-plots. Age of agri-horti plantation was 5-years old. Custard apple agri-horti system and open field recorded highest and lowest infestation of weeds, respectively. However, most of the growth, yield attributes and yield did not vary with agri-horti systems. 2-HW recorded the lowest infestation of weeds vis-à-vis maximum growth of mungbean. Application of imazethapyr 200 g a.i./ha recorded the lowest growth of predominant weed species, however, dry matter accumulation, yield attributes and yield of mungbean were comparable with imazethapyr 125 g a.i./ha.

Keyword : *Agri-horti system, Agroforestry, Weed dynamics, Nodule count, Biological yield*

Introduction

Pulses are an important source of dietary protein in the Indian diet. Interestingly, India is the largest producer (17–18 million tonnes production; 25 per cent of global production) and consumer (27 per cent of global consumption) of pulses in the world (Kumar *et al.,* 2014; Mohanty and Satyasai, 2015). Moreover, almost every year, India is importing 3–4 million tons of pulses to meet its annual demand of 21–22 million tonnes, of which 37.9 and 17.8 per cent of import were contributed by peas and mungbean, respectively (Reddy, 2014). It is worth noting, as per the recent estimate, by 2050 to fulfil the dietary needs of 1.69 billion populations, the projected requirement of pulses is nearly 32 million tonnes; which requires an additional area of 3.5 million ha under pulse production (Singh and Pratap, 2014). To achieve this will require multidimensional strategic planning for enhancing productivity, which includes both the technological improvement and horizontal expansion in area under pulse production.

Considering the above-said facts in view, there is a tremendous scope of increasing the area and productivity of pulses, by its introduction under the agroforestry systems. Actually, in India, agroforestry system is not a new concept; it is an age-old traditional practice, where the agricultural land is utilized for different purposes, like, food, feed, fibre, fuel, fruits, shelter, etc. (Sharma *et al.* 2017). Among the various agroforestry systems, agri-horticultural (agri-horti hereafter) system (growing of annual field crops along with fruit trees) is widely preferred by the farmers, because of its short gestation period, a recurrent source of income, and aesthetic value. Previous studies have demonstrated that during the initial 5–6 years of agri-horti plantation, alleys are effectively utilized for growing the annual crops (Shivran *et al.,* 2017). Introduction of pulses, particularly mungbean, in the alleys of agri-horti system provides an added advantage that it can build soil fertility and soil health, through the addition of atmospheric nitrogen fixation and organic matter. However, to realize the maximum tangible and intangible benefits by the introduction of annual crops in-between the alleys of perennial plantation primarily require analysis of compatibility between the main crop (tree crop) and annual introduced crop. Researches revealed many a time, introduction of annual crops fail to perform under alley cropping might be due to shading effect, negative interaction for utilization of natural resources or allelopathic incompatibility (Kumar and Singh 2014; Gupta *et al.,* 2018). Therefore, to reap the maximum benefit, care must be taken in species selection to avoid allelopathic effects and strong interspecific competition (Wolz and DeLucia, 2018).

At the same time, mungbean being a rainy (*kharif*) season crop is heavily infested with weeds, which reduce the yield by 25–50 per cent (Kumar *et al.* 2014). Traditionally, in India, manual weeding is the widely preferred option for weed management. However, due to increasing cost of manual weeding vis-à-vis shortage of labour for agricultural operations, the herbicide serves as one of the viable alternatives for weed management available to the farmers (Gupta *et al.,* 2018). Literature reveals that very few studies evaluated the compatibility of mungbean under the variable agri-horti system. At the same time, a meagre study systematically evaluated the use of herbicidal weed management of mungbean, particularly under agri-horti system. Therefore, the purpose of this investigation is to evaluate the effectiveness of herbicidal weed management options as well as a compatible agri-horti system for enhancing mungbean production.

Materials and Methods

Site and soil information

In the rainy season, the field experiment was conducted at the Agricultural Research Farm (location: $25^{0}10'$N latitude, $82^{0}37'$E longitudes, 365 m above the mean sea level) of Rajiv Gandhi South Campus, Banaras Hindu University, Mirzapur, Uttar Pradesh, India. The soil texture of the experimental field was sandy clay loam and slightly acidic (pH 6.2) in soil reaction. The nutritional status of soil showed low in organic carbon (0.29 kg/ha) and nitrogen, and medium in available phosphorus and potassium content. The total amount of rainfall received during the crop season was 879.00 mm, of which nearly 50 per cent was received in the month of September.

Trial establishment

The experiment was laid out in the split-plot design, having eighteen treatments, replicated thrice. The main plot comprised of three agri-horti systems, i.e. custard apple (*Annonas quamosa*), guava (*Psidium guajava*) and open field; whereas, in sub-plots consists of six weed management practices,including three herbicidal treatments, pendimethalin 1000 g a.i./ha (*Pendi*), imazethapyr 125 (*Imaz*125) and 200 (*Imaz* 200) g a.i./ha, compared with 1-hand weeding (*HW*) (20 DAS), 2-*HW* (15 and 30 DAS), and weedy check].

The experimental crop i.e. mungbean (variety: Samrat, seed rate: 15 kg/ha) was intercropped on 5^{th}August, between the alleys of guava (variety: Lucknow-49) and custard apple (variety: Mammoth) plantation. The plots of 3.0 × 4.0 m and 5.1 × 4.0 m size were prepared in custard apple and guava agri-horti system, respectively. The sowing was performed manually with a single row drill at 5 cm depth, having 30 cm row spacing. Before sowing, the seeds were treated with a suitable strain of rhizobium culture as per the procedure mentioned by Tripathi *et al*. (2012). At the time of sowing, the field was fertilised with the basal application of 20 kg N, 60 kg P_2O_5 and 40 kg K_2O in the form of urea, single super phosphate and muriate of potash. After dissolving in water (500 l/ha), the desired rate of pendimethalin and imazethapyr were sprayed as pre-emergence (PE, within 2-days of sowing) and post-emergence (PoE, at 20 days after sowing), respectively, with the help of knapsack sprayer, fitted with a flat-fan nozzle. The crop was harvested on October 19, 2011.

Biometrical observation

All the parameters are recorded at harvest, except nodule count, nodule dry matter and root dry matter which was recorded at 20 DAS. The above ground dry matter accumulation was determined by harvesting five plants from the interior rows (excluding the border rows); these rows were not used for yield determination. These plants samples were dried in an oven at 60 °C and then weighed. For the determination of nodule count, five plants were carefully excavated and placed in a plastic bag. In laboratory, these root samples were carefully washed under the running tap water above a sieve, separate the nodule from the root and then the number of nodule per plant was counted. After nodule counting, put the detached nodules in an oven for drying and nodule dry matter was determined. The total dry matter of root was determined by adding the excavated dried root with the nodule dry matter. Weed density and biomass were recorded at 40 DAS, by randomly placing the quadrat (dimension: 30 × 30 cm) at two selected spots each plot. The weeds, within the quadrat were cut at ground level, segregated species-wise, after counting the density of individual weeds, dried for 48 h in an oven at 60 °C, and then weighed to determine weed dry biomass.

Statistical analysis

Data recorded on crop and weed were statistical analysed using statistical software CPCS1 (Cheema and Singh, 1990). Before calculating analysis of variance (ANOVA), the weeds data were square-root transformed to produce a near normal distribution, whereas, the original data were presented in parenthesis. Critical differences were worked out at 5 per cent level of probability, where the 'F' test was significant.

Results and Discussion

During the experimentation, the field was infested with eleven rainy (*kharif*) season weeds. Out of the eleven weeds, nine were the annual monocot and two were the annual dicot weed species. The predominant weed species among the grasses were love grass (*Eragrosti spilosa* (L.) Beauv.), little barnyard grass (*Echinochloa colonum* (L.) Link). However, the old world diamond flower (*Oldendandia corymbosa* L.), and hairy spurge (*Euphorbia hirta*) among the broad leaved weeds (BLWs) and purple nutsedge (*Cyperus rotundus* L.) among the sedges are the predominant species.

The significantly lowest density and biomass of all the predominant weed species were recorded under the open field condition, followed by guava agri-horti system (Table 1 and 2). In fact, under open field condition the density and biomass of *E. pilosa* was completely absent, whereas, the density and biomass of *C. rotundus* was also drastically reduced over other agri-horti systems. The reduce density of all the predominating weeds under the open field condition might be explained by the fact that the micro-climatic conditions under the agroforestry systems are entirely different from the open field. The tree modifies the micro-climate of the alleys, in fact as compared to the open field, alley crops receives intermittent light, high humidity, moderate temperature regime (both ambient and soil temperature), high soil organic matter content due to litter decomposition, high moisture retention capacity and low evapo-transpiration loss (Muthuri *et al.*, 2014). Additionally, literature also reveals that the tree regulate the germination and growth of weeds through allelopathy (Rizvi *et al.*, 1999). These conditions might help in better emergence and establishment of weeds. These results further support the idea of Ramsey and Jose (2001), in which they observed that under pecan tree-cotton intercrop, plots under pecan tree was heavily infested with moisture and shade loving *Commelina communis*, whereas, the *Cynodonda ctylon* less prevalent under intercrop as compared to cotton monoculture due to niche specificity. Further, the trend analysis of mungbean growth, yield attributes and yield parameters clearly reflects that there was higher growth, yield attributes and yield was obtained under open field condition (Table 3). However, in most of the studied crop growth and yield parameters did not reach statistical significance, except nodule count, nodule dry matter, which showed significantly higher under open field. Higher trend in growth, yield attributes and yield parameters might be associated with better resource allocation due to comparatively lower weed infestation under open field condition over agri-horti systems.

Weed management practices recorded the significantly lowest density and biomass of predominating weeds under 2-HW as well as higher values of all the growth, yield attributes and yield parameters (Table 1, 2 and 3). These results are in agreement with those obtained by Singh *et al.* (2014), Patel *et al.* (2016). Among the herbicidal treatments, application of *imaz* 200 produced the lowest density and biomass of *E. hirta*, *O. corymbosa, C. rotundus*; however, the *imaz* 125 and *imaz* 200 produced almost similar results and recorded the lowest density and biomass of *E. pilosa*, and was statistically at par to 2-

Table 1. Effect of agri-horti system and weed management practices on density of predominant weeds in mungbean

Treatments		Density of weeds (number/m^2)[a]				
		Eragrostis pilosa	*Echinochloa colonum*	*Euphorbia hirta*	*Oldendandia corymbosa*	*Cyperus rotundus*
Agri-horti system (S)						
Guava		3.33 (16.22)	3.96 (18.00)	6.26 (46.89)	4.43 (23.56)	5.55 (38.67)
Custard Apple		3.74 (22.00)	5.15 (31.11)	7.96 (74.44)	5.88 (39.78)	7.27 (62.44)
Open field		1.00 (0.00)	2.90 (11.11)	4.25 (20.22)	3.31 (13.33)	2.64 (9.78)
SEm±		0.09	0.16	0.14	0.08	0.28
CD (P=0.05)		0.37	0.69	0.60	0.33	1.17
Weed Management Practices (W)						
Pendimethalin	1000 g/ha (PE)	4.21 (22.67)	5.68 (32.00)	7.76 (64.00)	5.75 (32.89)	7.57 (60.89)
Imazethapyr	125 g/ha (PoE)	1.00 (0.00)	3.86 (17.33)	6.61 (45.78)	5.03 (26.67)	5.09 (33.78)
Imazethapyr	200 g/ha (PoE)	1.00 (0.00)	3.19 (13.78)	5.50 (31.56)	2.92 (11.11)	3.64 (18.67)
1-Hand Weeding	(20 DAS)	3.42 (13.78)	3.70 (12.89)	6.42 (44.00)	5.15 (27.11)	5.01 (29.33)
2-Hand Weeding	(15 & 30 DAS)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
Weedy Check		5.51 (40.00)	6.60 (44.44)	9.67 (97.78)	7.38 (55.56)	8.63 (79.11)
SEm±		0.15	0.23	0.23	0.23	0.25
CD (P=0.05)		0.42	0.66	0.65	0.67	0.72

Data are subjected to square root transformation. Original values are given in the parenthesis. [a]observationwere recorded at 40 DAS.

Table 2. Effect of agri-horti system and weed management practices on biomass of predominant weeds in mungbean.

Treatment		Biomass of weeds (g/m^2)[a]				
		Eragrostis pilosa	*Echinochloa colonum*	*Euphorbia hirta*	*Oldendandia corymbosa*	*Cyperus rotundus*
Agri-horti system (S)						
Guava		1.51 (1.61)	2.03 (3.55)	2.31 (5.07)	1.65 (1.97)	1.73 (2.30)
Custard Apple		1.74 (2.73)	2.62 (6.92)	3.03 (9.60)	1.94 (3.07)	2.16 (4.13)
Open field		1.00 (0.00)	1.63 (2.08)	1.95 (3.29)	1.49 (1.41)	1.39 (1.18)
SEm±		0.02	0.05	0.06	0.04	0.07
CD (P=0.05)		0.10	0.21	0.24	0.15	0.29
Weed Management Practices (W)						
Pendimethalin	1000 g/ha (PE)	1.77 (2.52)	2.71 (6.54)	3.09 (8.88)	2.05 (3.26)	2.33 (4.53)
Imazethapyr	125 g/ha (PoE)	1.00 (0.00)	1.99 (3.47)	2.42 (5.04)	1.74 (2.10)	1.68 (2.06)
Imazethapyr	200 g/ha (PoE)	1.00 (0.00)	1.77 (2.64)	2.10 (3.66)	1.28 (0.74)	1.45 (1.41)
1-Hand Weeding	(20 DAS)	1.56 (1.61)	1.91 (2.65)	2.17 (4.04)	1.72 (1.99)	1.57 (1.64)
2-Hand Weeding	(15 & 30 DAS)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
Weedy Check		2.18 (4.54)	3.19 (9.80)	3.81 (14.30)	2.39 (4.79)	2.54 (5.60)
SEm±		0.05	0.09	0.08	0.06	0.06
CD (P=0.05)		0.13	0.25	0.24	0.16	0.17

Data are subjected to square root transformation. Original values are given in the parenthesis. [a]observation recorded at 40 DAS.

Table 3. Influence of agri-horti system and weed management practices on crop growth, yield attributes and yield of mungbean.

Treatment	Above ground dry matter (g/plant)	Nodule count (No./plant)[a]	Nodule dry matter (mg/plant)[a]	Root dry matter (mg/plant)[a]	Length of pod (cm)	1000-grain weight (g)	Biological yield (kg/ha)	Straw yield (kg/ha)
Agri-horti system (S)								
Guava	12.50	6.83	8.12	30.11	6.32	30.13	2767.23	2051.89
Custard Apple	12.48	6.68	7.97	29.22	6.30	29.92	2705.46	2013.56
Open field	12.70	7.48	8.16	32.83	6.34	30.69	2847.57	2119.17
SEm±	0.10	0.14	0.03	1.13	0.02	0.19	26.22	21.01
CD (P=0.05)	NS	0.58	0.11	NS	NS	NS	NS	NS
Weed management practices(W)								
Pendi1000 g/ha(PE)	11.32	7.24	8.58	35.51	6.20	29.32	2499.97	1868.00
Imaz 125 g/ha (PoE)	11.42	6.73	7.56	28.22	6.21	29.60	2885.85	2128.22
*Imaz*200 g/ha (PoE)	14.01	6.93	7.98	28.78	6.50	31.38	3036.77	2249.11
1–HW (20 DAS)	13.08	6.91	7.79	29.11	6.24	29.90	2993.20	2225.33
2–HW (15&30 DAS)	14.55	7.58	8.77	34.00	6.64	32.82	3374.46	2485.67
Weedy Check	10.98	6.58	7.81	28.67	6.12	28.47	1850.28	1412.89
SEm ±	0.38	0.19	0.15	1.21	0.02	0.19	57.81	46.49
CD (P=0.05)	1.09	0.54	0.45	3.48	0.05	0.55	166.94	134.24

Pendi = Pendimethalin, Imaz = Imazethapyr, HW = Hand Weeding, [a] observation recorded at 20 DAS

HW. Furthermore, *imaz* 200 recorded lower density of *E. colonum*; however both the rates of *imaz* produced similar lowest biomass of *E. colonum* and were comparable to 1-HW. In previous experiment conducted by Singh *et al.* (2014) and Kumar *et al.* (2016) tested variable rates of *imaz* up to 100 g a.i./ha, and highest dose proves best treatment, however, in our experiment we have tested two rates of *imaz* 125 and 200 g a.i./ha and observed better management of predominant weeds at *imaz* 200, moreover, phytotoxic effect of higher dose was noticed on crops for about 10-days. Among the herbicidal treatments, *imaz* 200 consistently produced higher length of pod, 1000-grain weight, biological yield and straw yield (Table 3); however, the biological yield, grain yield (data not shown) and straw yield were statistically at par with *imaz* 125 and 1-HW (20 DAS). Further, data recorded at 20 DAS showed higher nodule number, nodule dry matter and root dry matter with the application of *pendi*. This result are in line with those of previous studies, which found that application of *pendi* at recommended rate cause transient inhibition of bacterial population, thereafter, exhibited significant increase in population over control (Singh *et al.,* 2020). Further, *imaz* at both the rate, applied just 20 DAS before observation, might have some toxic to the bacteria. Considering these facts, it is always advisable, to choose lower rate of *imaz*125, which produce comparable yield to *imaz*200 without deteriorating the soil environment.

Based on the above-said experiment, it can be concluded that though the different agri-horti system have led to variability in level of weed infestation, but have no significant impact on mungbean growth and yield. Thus, mungbean is found compatible for production under custard apple and guava agri-horti system. Further, 2-hand weeding (20 and 40 DAS) is the most efficient method of managing weeds and has positive impact on growth and yield of munbean. However, under labour scarcity, application of imazethapyr 125 g a.i./ha is the recommended for managing weeds and enhancing productivity of mungbean.

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